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JUNE 1963

OOAMA

AIRMUNITIONS TEST REPORT

SERVICE AND SHELF LIFE OF EXPLOSIVE SWITCH P/N 1186 FOR T3019E5 ARMING PROGRAMMER IM99A MISSILE

2705th AIRMUNITIONS WING
OGDEN AIR MATERIEL AREA
UNITED STATES AIR FORCE • HILL AIR FORCE BASE, UTAH

SERVICE AND SHELF LIFE OF

EXPLOSIVE SWITCH P/N 1186 FOR

T3019E5 ARMING PROGRAMMER

IM99A MISSILE

by

Don F. Woods

PUBLICATION REVIEW

This report has been reviewed and is approved

L Mondfort for
ALEX D. PERESICH
Chief, Engineering and
Test Division
2705th Airmunitions Wing

JUNE 1963

2705TH AIRMUNITIONS WING
OGDEN AIR MATERIEL AREA
AIR FORCE LOGISTICS COMMAND
UNITED STATES AIR FORCE
Hill Air Force Base, Utah

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The conclusions and recommendations made in this report are not to be considered directive in nature. This type information becomes official only when published in Technical Orders or other applicable Air Force publications.

Qualified requesters may obtain copies of this report from DDC.

ADMINISTRATIVE DATA

PURPOSE OF TEST:

The purpose of this test was to determine if the service life of Explosive Valve, P/N 1186 for T3019E5 Arming Programmer could be extended.

MANUFACTURER:

Raymond Engineering Laboratories, Inc, Middletown, Connecticut

ITEM IDENTIFICATION:

Federal Stock Number 1336-794-8729

Part Number 1186

Nomenclature, Explosive Switch

Module P/N 10406468

QUANTITY OF ITEMS TESTED:

58 Explosive Switches (29 switch modules)

22 Hot (120°F)
26 Cold (-40°F)

SECURITY CLASSIFICATION:

Unclassified

DATE TESTED:

April 1963

TEST CONDUCTED BY:

OOAMA (OOYET - 2705th Airmunitions Wing)

Test Director: Richard O. Miller, Captain, USAF
Project Officer: Don F. Woods, Mechanical Engineer
Test Directive: M-3-822-Y

DISPOSITION OF SPECIMENS:

All metal components, generated from this test were inspected and certified inert in accordance with Technical Order 11C3-1-3. These components were then turned over to the Redistribution and Marketing Division.

INTRODUCTION

The REL 1186 Explosive Switch is used in the T3019E5 Arming Programmer and is part of the IM99A (Bomarc) Weapon System. The purpose of the switch is to break and make two electrical circuits during the flight of the missile.

Currently the explosive switch has a three year service life. The arming programmers are normally cycled through the OOAMA maintenance facility every 16 months. Therefore, two cycles (32 months) is the maximum time that the switches can be used. Testing was accomplished to determine if the service life of the explosive switch could be increased so that the switches could be used for three cycles (48 months) or possibly four cycles.

The tests were conducted under Test Directive M-3-822-Y prepared by the Ground Launch Missile Branch, 2705th Airmunitions Wing.

DESCRIPTION

The REL 1186 Explosive Switch is a two circuit transfer device actuated by electric ignition of a small amount of lead styphnate. The gas produced from the explosive causes a metal disk shorting two contacts (normally closed circuit) to be forced off from these contacts and across two other contacts (normally open contacts), causing one circuit to open and one circuit to close. The switch does not rupture upon activation. The external appearance is unchanged.

The switch is about 0.56 inch long and 3.8 inches in diameter. The sheath is a brass cylinder. Four leads, from the electrical contacts, extend from one end. The leads from the explosive bridge wire, extend from the other end. The switch is sealed with potting compound.

Two switches (for redundancy) are used in each arming programmer. The two switches and a connecting plug are potted together forming a switch module (Figures 1A and 1B). The internal wiring of the module is shown in Figure 2.

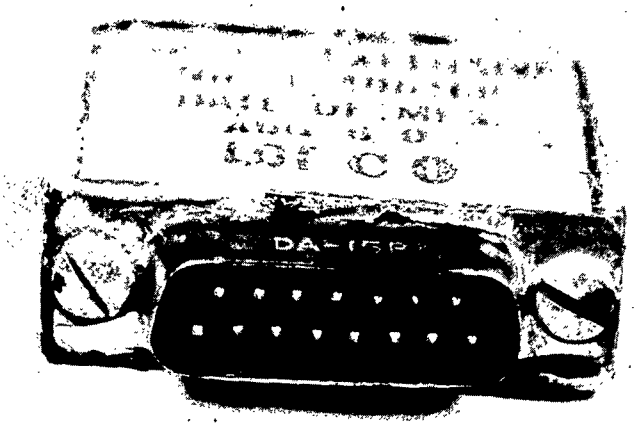


FIGURE 1A. Explosive Switch Module.

FIGURE 1B. Explosive Switch Module.

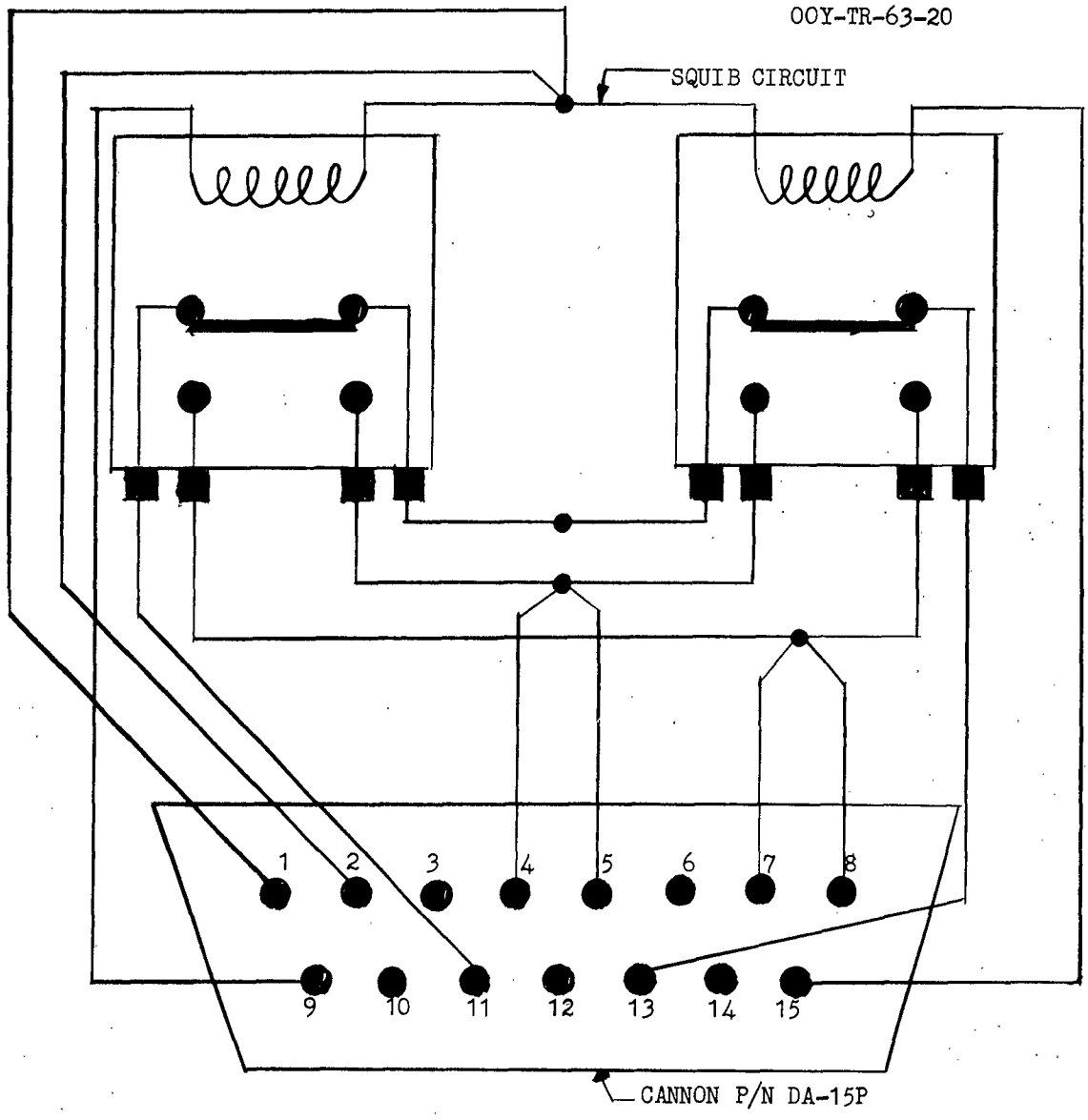


FIGURE 2. Internal Electrical Schematic of Switch Module

TEST SAMPLES

The test samples were obtained from arming programmers during their maintenance recycle. Twelve samples were manufactured in March 1960. These items were from lot CM. The remaining 46 switches were manufactured in January 1960. The lot designator for these switches is unknown.

TEST PROCEDURES

TEMPERATURE CONDITIONING

Eleven switch modules were conditioned at 120°F and 18 switch modules were conditioned at -40°F for 24 hours before testing.

PRE-FUNCTIONING INSPECTION

Prior to functioning, the electrical circuits were checked for resistance and continuity as follows (refer to Figure 2):

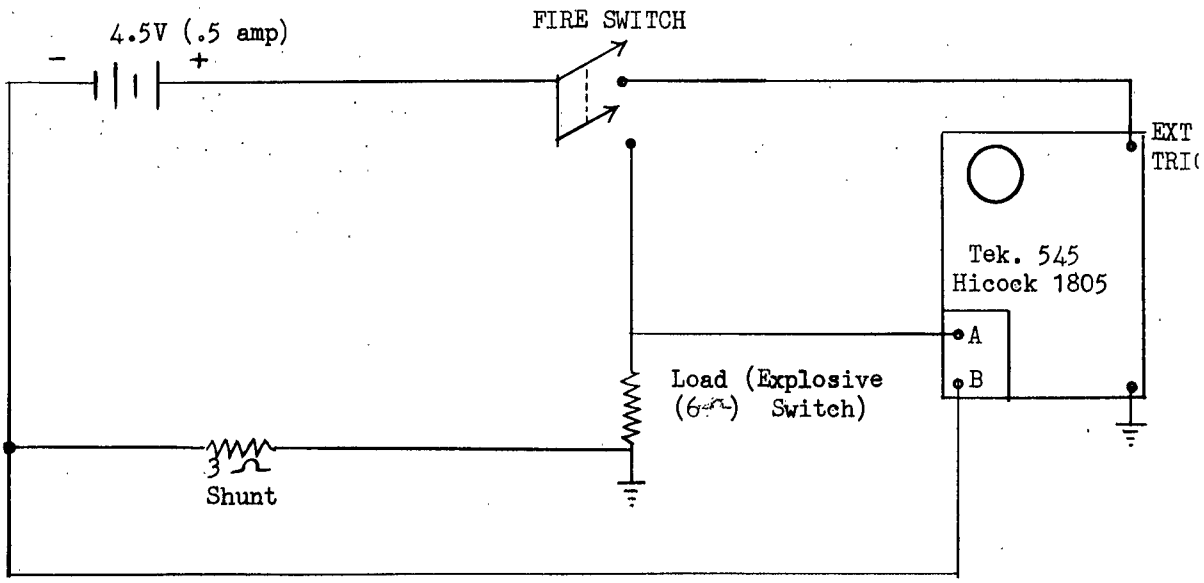
1. Pins 1 and 9, and 1 and 15 were checked for continuity using an ohmmeter.

2. Pins 11 and 13 were checked for continuity using an ohmmeter.

3. Pins 4 and 7 were checked for electrical insulation resistance using a 500 volt insulation test set.

STATIC FUNCTIONING

Each of the two switches inside a module were tested independently by applying a firing current to pins 1 and 9 and then pins 1 and 15 (Figure 2). The switches were fired using an electrical arrangement and oscilloscope as shown in Figures 3 and 4. The firing pulse across the face of the oscilloscope was photographed. In this manner firing current, firing voltage and ignition delay were obtained for each switch. The energy required for firing was then calculated. Figure 5 is a typical firing trace.



'A' input
1.5V C/M
polarity - "Inverted"
Zero Reference - Top line

'B' input
.5V C/M
polarity - "Inverted"
Zero Reference - Bottom line

Trigger = "+ Ext"
Mode = "DC"
Sweep = "200 u sec C/M"
Magnifier - "Off"
Main Sweep - "Normal"

FIGURE 3. Static Firing Schematic Electrical Hook-up.

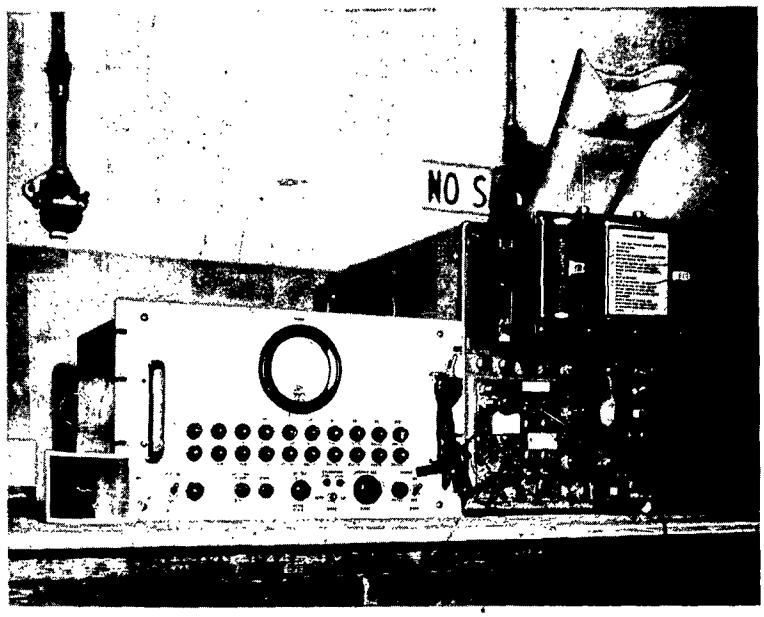


FIGURE 4. Test Set-Up.

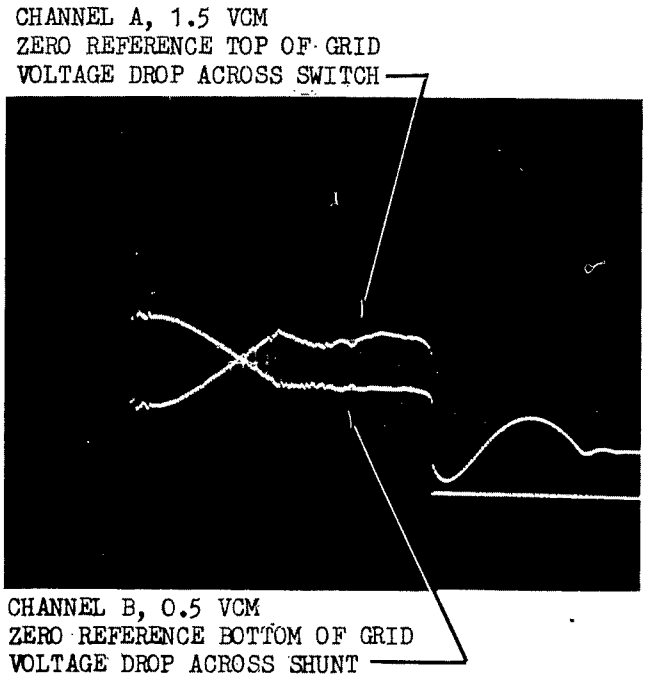


FIGURE 5. Typical Firing Trace - 40°F.

POST FUNCTIONING INSPECTION

After firing electrical circuits 1 and 9, 1 and 15, and 11 and 13 were checked for the expected open condition using a 500 volt electrical insulation checker. Circuit 4 and 7 was checked for continuity with an ohmmeter.

All switches modules were radiographed to verify that both switches inside the module functioned. This could not be determined electrically because of the parallel hook-up of the two normally open contacts and the series hook-up of the normally closed contacts inside the module (Figure 2).

TEST RESULTS

PRE-FIRING INSPECTION

The resistance of both squib circuits (pins 1 and 9, and 1 and 15 were within specification (6 ± 2 ohm) for all switch modules. Circuits 11 and 13 were closed (resistance below the capacity of the instrument to record). The normally open circuit (pins 4 and 7) had a resistance greater than the range of the 500 volt insulation tester (1000 megohm). Table 1 contains tabulated test results.

STATIC FUNCTIONING

A fire pulse was observed for each switch indicating that the bridge wire had broken. Most fire pulses were recorded by camera. A few pulses were not recorded due to equipment failure. All traces obtained were similar in appearance (Figure 5). Table 1 contains a tabulated record of the firing voltage, firing current, ignition delay and energy input level for each switch.

POST FIRING INSPECTION

Electrical check of the switch module revealed that:

1. The bridge circuit (pins 1-9 and 1-15) were open (normal).
2. Circuit 4-7 was closed (normal).
3. Circuit 11-13 was open (normal).

SWITCH NUMBER	FIRING VOLTAGE (VOLTS)	FIRING CURRENT (MILLI-AMPS	TIME TO OPEN IGNITION BRIDGE (MICRO-SECONDS)	ENERGY TO IGNITE (ERGS)	BRIDGE RESIST-ANCE (OHM)	AGE (MO)	FIRING TEMP (°F)	LOT NUMBER
1,1-9	1.95	300	800	4690	6.49	38	120	CM
1,1-15	2.10	300	800	5050	6.69	38	120	CM
2,1-9	2.10	300	800	5050	6.13	40	120	Unknown
2,1-15	1.80	333	640	3830	4.96	40	120	Unknown
3,1-9	2.10	267	980	4830	7.15	40	120	Unknown
2,1-15	1.35	300	860	3480	6.06	40	120	Unknown
6,1-9	1.65	300	680	3370	5.64	40	120	Unknown
6,1-15	1.65	333	680	3740	4.20	40	120	Unknown
7,1-9	2.40	300	760	5460	6.78	40	120	Unknown
7,1-15	1.80	317	720	4110	5.45	40	120	Unknown
9,1-9	1.95	300	840	4910	6.10	38	120	CM
9,1-15	1.50	333	750	3750	5.16	38	120	CM
10,1-9	2.08	283	980	5760	6.45	40	120	Unknown
10,1-15	NOT OBTAINED				5.91	40	120	Unknown
11,1-9	2.25	300	1080	7300	6.88	40	120	Unknown
11,1-15	1.50	350	720	3780	5.33	40	120	Unknown
13,1-9	2.10	311	1280	8360	5.80	38	120	CM
13,1-15	1.95	300	680	3980	6.27	38	120	CM
15,1-9	1.65	317	740	3870	5.52	40	120	Unknown
15,1-15	1.95	317	800	4950	5.91	40	120	Unknown
17,1-9	2.25	300	800	5400	6.32	40	120	Unknown
17,1-15	NOT OBTAINED				5.85	40	120	Unknown
19,1-9	1.8	317	860	4900	6.14	40	-40	Unknown
19,1-15	NOT OBTAINED				6.66	40	-40	Unknown
20,1-9	1.95	317	720	4450	5.53	40	-40	Unknown
20,1-15	1.65	317	1080	5650	6.68	40	-40	Unknown
21,1-9*	1.95	317	760	4700	5.06	40	-40	Unknown
21,1-15	2.40	266	960	6130	8.28	40	-40	Unknown
22,1-9	2.40	317	760	5790	6.64	38	-40	CM
22,1-15	1.80	350	760	4790	4.99	38	-40	CM
23,1-9	1.80	300	720	3880	4.70	40	-40	Unknown
23,1-15	2.70	266	1000	7190	6.74	40	-40	Unknown
25,1-9	1.95	300	820	4800	6.09	40	-40	Unknown
25,1-15	2.55	300	580	4440	6.80	40	-40	Unknown

TABLE 1. Test Data Sheet. (Continued on next page.)

*Switch malfunctioned.

SWITCH NUMBER	FIRING VOLTAGE (VOLTS)	FIRING CURRENT (MILLI-AMPS	TIME TO OPEN IGNITION BRIDGE (MICRO-SECONDS)	ENERGY TO IGNITE (ERGS)	BRIDGE RESIST-ANCE (OHM)	AGE (MO)	FIRING TEMP (°F)	LOT NUMBER
26,1-9	2.10	317	920	6130	7.73	40	-40	Unknown
26,1-15	2.10	317	920	6130	6.57	40	-40	Unknown
27,1-9	2.10	283	840	5000	5.84	38	-40	CM
27,1-15*	2.70	251	1100	7450	7.62	38	-40	CM
28,1-9	0.9	317	720	2060	5.19	38	-40	CM
28,1-15	1.05	350	920	3380	5.52	38	-40	CM
29,1-9	1.65	333	680	3740	5.30	40	-40	Unknown
29,1-15	2.10	300	880	5550	6.43	40	-40	Unknown
30,1-9	1.80	333	680	4090	5.01	40	-40	Unknown
30,1-15	1.20	333	760	3040	5.43	40	-40	Unknown
31,1-9	1.50	317	960	4560	5.59	40	-40	Unknown
31,1-15	2.55	250	740	4730	5.81	40	-40	Unknown
32,1-9	1.50	333	940	4700	5.84	40	-40	Unknown
32,1-15	1.65	333	820	4500	5.84	40	-40	Unknown
33,1-9	2.25	300	920	6220	6.61	40	-40	Unknown
33,1-15	1.50	333	800	4000	5.32	40	-40	Unknown
34,1-9	2.40	300	960	6910	6.38	40	-40	Unknown
34,1-15	2.10	300	1080	6800	7.11	40	-40	Unknown
35,1-9	1.95	300	1000	5850	6.82	40	-40	Unknown
35,1-15	1.65	333	840	4620	5.79	40	-40	Unknown
37,1-9	NOT OBTAINED				4.88	40	65	Unknown
37,1-15	NOT OBTAINED				4.91	40	65	Unknown
38,1-9	2.10	333	600	4200	4.91	40	65	Unknown
38,1-15	2.25	300	920	6220	6.57	40	65	Unknown

TABLE 1. (Continued from previous page) Test Data Sheet.

*Switch malfunctioned.

Radiographic inspection, however revealed that one switch in each of two modules had not functioned. Figures 6A and 6B are radiographs showing the internal details of the switches. One switch was manufactured in January 1960 and one in March 1960.

Apparently the bridge wire had burned open but the explosive had not functioned. In order to determine the cause of the defects, the two faulty switches were carefully dissected by filing away switch material and inspecting the internal structure as the filing proceeded.

One switch was inspected by filing away from the side of the switch. The second switch was inspected by filing away from the top of the switch.

Filing away the switch from the side did not reveal any explosive or bridge wire. This method of inspection was not satisfactory for dissecting the switch, because such a small amount of explosive is present that it cannot be seen from the side.

The second switch was filed from the top. The potted end of the lead wires with a thin film of explosive was obtained intact (Figure 7). The explosive was scraped away between the lead wire ends revealing that the bridge wire between the lead wires was missing. A tiny portion of the explosive was removed and checked for ignitability by contact with the flame from a match. The explosive detonated with an audible report indicating that it was still sensitive to heat.

As the one sample was filed down from the top, the lead wires were visible. One lead wire was observed to have been inserted in a folded (accordian) like position. The cross section of this wire at various depths from the top of the switch toward the bridge, was not round but rectangular as would be obtained from filing the side of the wire. This folding caused the two lead wires to almost touch at several points. It is conceivable that lead wires inserted in this manner could touch each other, effectively shorting out the bridge. It is not likely that the switches malfunctioned in this way, since the resistance of the bridge circuit was normal for the two switches (5.06 ohm and 7.62 ohm). Also, the bridge wire was not found under the explosive.

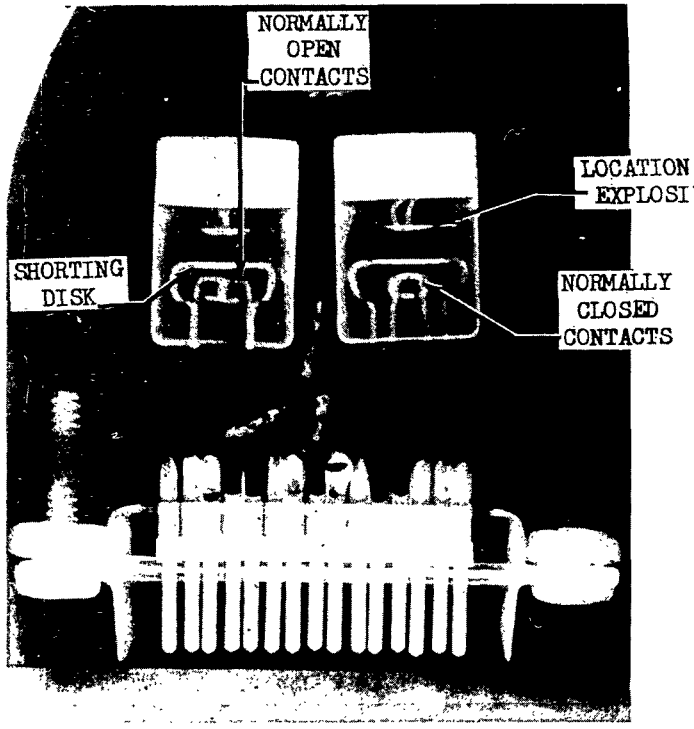
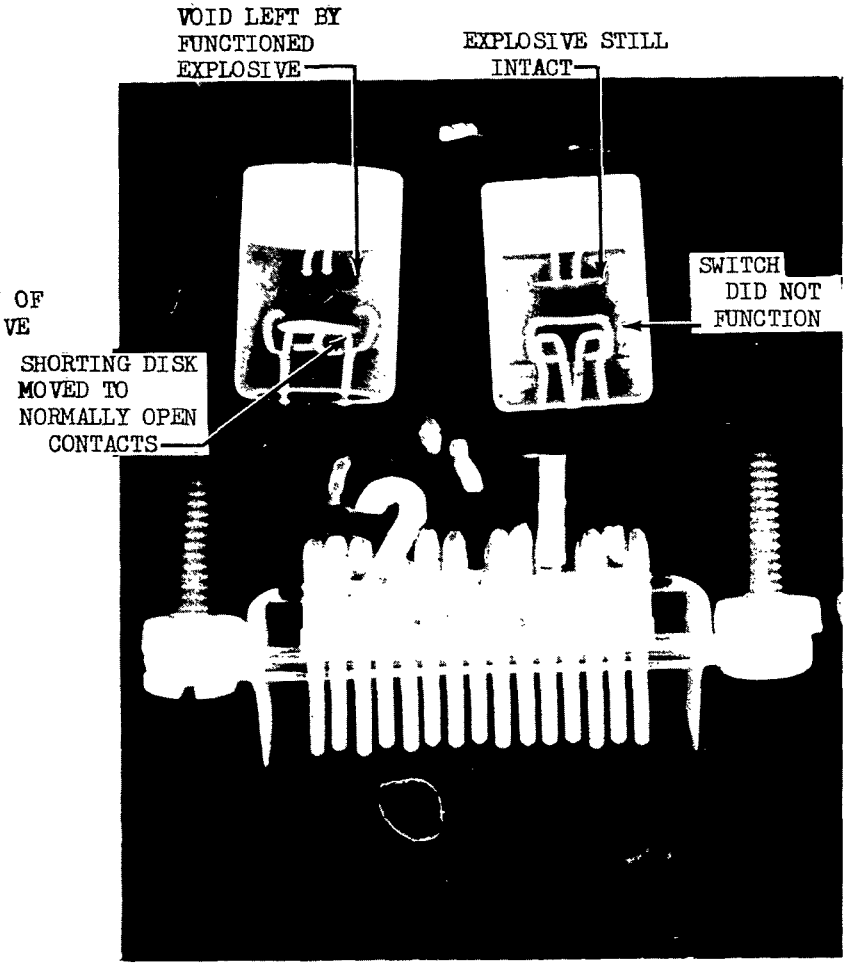
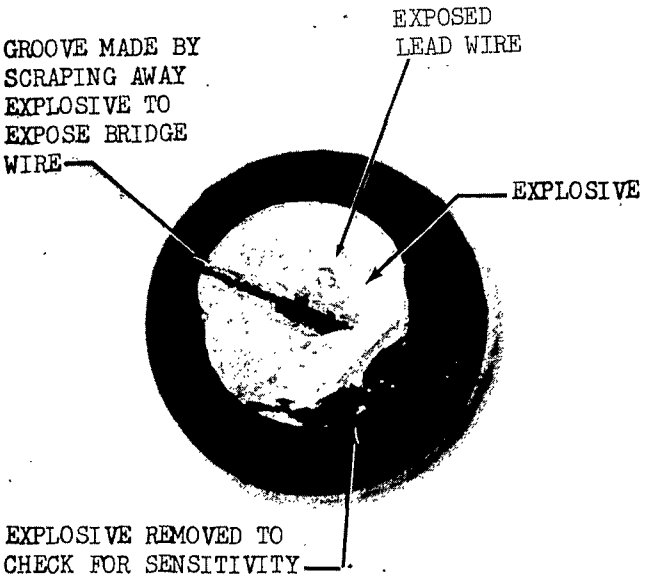


FIGURE 6A. Radiograph of Unfired Switch Module



FIGUTR 6B. Radiograph of Fired Switch Module



MAGNIFIED APPROXIMATELY 7 TIMES

FIGURE 7. Explosive Film Intact After Switch Received Fire Pulse.

Two switches that had functioned were then dissected, for comparison. The lead wires in both of these switches extended vertically into the switch without any folding. The spacing between these wires was adequate at all times to prevent shorting.

Two possible causes for failure of the switch are:

1. The explosive immediately around the bridge wire was melted away from the bridge or desensitized from the application of stray voltages or test voltages less than that required for detonation.

2. The bridge wire and explosive were not in intimate contact at the time of manufacture.

CONCLUSIONS AND RECOMMENDATIONS

It is our opinion that the failure of the two switches was due to isolated causes and not the result of aging. This opinion is substantiated by the fact that all of the other switches tested functioned satisfactorily without evidence of degradation. If aging were the cause of the switch failures, it would be reasonable to expect its effects to show up in a fairly high percentage of samples of the same age and lot.

The ability of the REL 1186 Explosive Switch to function cannot be positively determined by non-destructive tests (electrical check-outs or by radiographs). This statement excludes obvious defects such as an open bridge circuit, missing parts, etc. Reliability must be insured by aggressive quality control during manufacture and a well designed quality assurance test program of completed articles.

The minimum (no worse than) reliability demonstrated by the switches was 89.5 per cent at a confidence limit of 95 per cent. Considering redundancy (two switches within one module). The reliability demonstrated was 98.9 per cent at a 95 per cent confidence limit.

The REL 1186 explosive switch functioned satisfactorily after 40 months in service.

It is recommended that the service life be extended to 54 months from the date of manufacture.

DISTRIBUTION LIST

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SERVICE AND SHELF LIFE OF EXPLOSIVE SWITCH P/N 1186 FOR T3019E5 ARMING PROGRAMMER IM99A MISSILE, by Don F. Woods, June 1963, 15p incl. figures and tables.
(OOY-TR-63-20) Unclassified Report

The REL 1186 Explosive Switch is used in the T3019E5 Arming Programmer to break and make electrical circuits during the flight of the IM99A Bomarc Missile. The current service life of the switch is 36 months. Arming Programmers are cycled through the OOAMA Maintenance Facility about every 16 months. Therefore, a maximum of two cycles (32 months) is all the use that can be obtained from an individual switch. The purpose of this test was to determine if the service life could be extended so that three or more cycles of use could be realized from the switches. Fifty-eight samples were tested (29 modules with two switches wired in parallel for redundancy). These specimens were inspected, functioned and radiographed. The fire pulse for each switch was monitored and recorded by an oscilloscope and camera arrangement. Firing voltage, firing current, ignition delay and the energy required to open the bridge circuit were calculated. Fifty-six switches functioned satisfactorily. Two switches malfunctioned. These were not in the same module; therefore, all modules would have performed their intended function. It is considered that the malfunctions were not the result of degradation caused by aging. The minimum reliability demonstrated by the switches was 89.5 per cent at a 95 per cent confidence level. Considering the redundancy of the system (two switches in parallel) the demonstrated reliability was 98.9 per cent at a 95 per cent confidence limit. It is recommended that the service life of the REL 1186 Explosive Switch be extended to 54 months from the date of manufacture.

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I. Don F. Woods

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